

Chapter III -- Data Acquisition and Availability

Data are always a problem in the maritime world. Widely separated observing sites require large interpolations and extrapolations when analyses, some of the basic tools used by forecasters, are made. One product that CPHC forecasters used early in the life cycle of Iniki was the Deep Layer Winds and Wind Shear Analysis. The area1 extent of this product, however, does not reach far enough west to include Hawaii. **DST Recommendation: The NMC should extend the Deep Layer Mean Winds and Wind Shear Analysis west to the International Dateline.**

Satellite Data

By far, the most important aides available to the CPHC forecasters were the GOES-7 imagery. These data were received every half hour during the entire period of the storm and consisted of the following:

1. Visual imagery every half hour during daylight hours.
2. Full disc unenhanced infrared every hour.
3. Enhanced infrared imagery every half hour during night time hours.
4. Water vapor imagery every hour.

The NWS has one fully operational geostationary satellite positioned over the equator at 112°W longitude. The configuration planned for NWS operations would normally include two GOES satellites. The lack of the second satellite, which would have been located at about 135°W, resulted in some operational problems for the CPHC forecasters primarily due to the large longitudinal angle between the storm and the satellite. Overall, however, the one satellite configuration provided adequate coverage of Iniki.

To augment the existing satellite, CPHC also receives data from the Japanese GMS. At the present time, it receives four sectors of the low resolution unenhanced infrared imagery every three hours, Hawaii is near the eastern edge of the northeast sector. Accuracy of fixes between 170 and 160°W would be, at best, degraded. Beyond 160°W, where most of the Hawaiian Islands are located, accurate fixes are close to impossible.' Although upstream weather features that influenced Iniki were seen by this satellite, GMS coverage did not enable forecasters to see the hurricane.

Determining exact storm positions was the biggest difficulty. CPHC does not have the capability to calculate needed adjustments between apparent location and actual location for storms in its area. The Synoptic Analysis Branch (SAB) of the National Environmental Satellite, Data and Information Service was able to provide some compensation estimates during periodic coordination calls. However, SAB estimated that position error estimates were up to 20 NM. Actual usage by CPHC forecasters could not be determined.

In addition to determining position, satellite images are used to determine winds, especially upper level winds. These data are automatically generated at NMC and input into the AVN model. The large angle between the satellite and the area around the storm as it approached Hawaii did not allow winds north and west of Iniki, those that led to its northward turn, to be

determined. Some compensation for this lack of data, however, was achieved by using data from the GMS and from commercial aircraft observations.

The satellite section of the WSFO proved invaluable during this episode. Using techniques developed by Vernon Dvorak, the staff of this section was principally responsible for determining the past track and initial positions used in all of the numerical forecasting tools and for estimating Iniki's intensity. Given the limitations imposed by the single GOES and given the problems inherent in finding a disturbance center when the storm is not very intense or is in an environment of relatively large vertical shears, this was sometimes a difficult task. **DST Recommendation: NWS management should insure that the satellite section currently in place be retained.**

Further, the increasing possibility that the existing GOES will fail before its replacement is in place is of major concern. Back up systems, such as direct access to polar orbiting satellite data, are not now available. Currently, polar orbiting information is received by Hickam AFB and, time and resources permitting, the associated transparencies are transmitted to the CPHC via the back side of its GOES-TAP line. The DST does not believe that this system is sufficient. Without satellite information, it is most likely storms such as Iniki will not be detected until they approach land. A HIPS is being procured that will provide this direct access. **DST Recommendation: The NWS should expedite the installation of systems, such as HIPS, to provide the CPHC with direct access to polar orbiting satellite data. Also, the NWS should consider providing the CPHC with capabilities for archiving selected GOES photographs and for directly accessing other data available via satellite. This would include tide gage data currently available from the GOES.**

Surface Observations

During most of its lifetime a tropical cyclone remains over oceans, the most data-sparse sections of the globe. Satellites, which provide imagery for virtually the entire earth, are the prime tool used for detecting and tracking these storms. However, at present they do not provide in situ data for forecasting various storm characteristics (wind speeds, storm movement, etc.). Therefore, surface data sources, although widely separated, must also be available to assist forecasters in issuing accurate warnings.

Buoys

Outside of satellite data, buoys provide the most stable data set for ocean environs. Four weather buoys are sited around Hawaii with three along its southern flank (indicated by stars in Figure 8). Providing information once an hour, these were the main sources of sea height information available to CPHC staff. In general, the buoys are sited far enough apart that a small, intense storm, like Iniki, could sneak between without its true nature being detected. The west wall of the eye passed less than 60 miles east of Buoy 51003. However, this puts the buoy in the weaker part of the storm. Wind speeds of about 45 MPH gusting to 55 MPH and seas of about 18 FT were the highest recorded. The lowest measured pressure was 996.5 MB.

Land-based Observations

Land-based observational data from Pacific Region stations are not sent directly to WSFO Honolulu and CPHC. The recorded information, like almost all other alphanumeric data received on Hawaii, is sent over the Leased Service A and B System (LABS), a system using the existing telephone network, to the mainland United States where it must be received by the Weather Service Message Center (WSMC) in Kansas City and forwarded to the NWS Telecommunications Gateway. From there it is routed to the PRIME computer system, the Pacific Region's internal communication and processing system. As a backup, observations are returned via the LABS to WSFO Honolulu directly from WSMC. Whenever a communications outage occurs, either within Hawaii, within the critical communications systems on the mainland, or within the WSMC itself, all data to WSFO Honolulu and the CPHC from affected sites are lost.

The only backups to this are regular telephone lines or radio. On other Pacific island WSOs backup radio systems have been installed due to the unreliability of local telephone systems. However, the reliability of telephone communications across Hawaii led to the belief that such were unnecessary within the state. This belief was proven wrong by Iniki. This was previously noted in a National Academy of Science report written after Hurricane Iwa in 1982. Downed telephone lines and destroyed telephone relays triggered major communications outages across all of Kauai within four hours of landfall. **DST Recommendation: The NWS should require installation of reliable, independent, backup communications with the WSO in Lihue (and other Hawaiian WSOs).**

As a result of the telephone outages, CPHC lost all observations from Kauai as the storm approached, crossed the island, and departed. Especially critical were losses of wind reports from the MWT at Makahuena Point and from WSO Lihue. The last report from the Point was received at 1 p.m. HST on September 11, 1992. Gusts at this time were as high as 60 MPH. Aside from a peak gust measurement retrieved when communications with the instrument restored over a week after the storm, all other data from this site were lost. The final report from the WSO was received at 1:40 p.m. HST and showed gusts approaching 70 MPH. Direct communications from WSO Lihue were not restored until September 14, 1992. The LABS circuit was not restored until October 7, 1992.

Despite the outages and the fury of the storm, operations at WSO Lihue generally continued uninterrupted. Backup power supplies within the office and from the airport and manual observing instruments allowed surface observations to be taken throughout. The lack of communications, however, prohibited any of the information from being transmitted.

Because of the communications problems, and due to safety considerations, the Official in Charge (OIC) decided to not fly several upper air soundings from 00 UTC September 12, 1992, to 12 UTC September 14, 1992. Except for safety, the DST believes that NWS observers should take and record all scheduled observations even if communications problems preclude them from being immediately distributed. **DST Recommendation: The NWS needs to implement a policy that, except when safety considerations prevent, upper air soundings and other observations be taken at NWS facilities even though communications are disrupted.** Even though the data are not available for operational forecast purposes, they still are valuable for research and climatological functions.

Further, the backup power supply for the HO83 system (the system that automatically measures temperature and dew point) is supplied by the airport. Although this was sufficient during the storm, the power was turned off periodically during the cleanup activities requiring the observers to use backup, manual instruments. **DST Recommendation: The NWS should require that all critical observing systems have reliable backup power preferably under NWS control.**

The loss of some electrical equipment in the office and the impact of Iniki on automated observing sites scattered throughout the island highlighted the need for ET support at Lihue. An attempt was made to fly an ET to Lihue the day before the storm struck. Logistic problems and higher priority passengers prohibited this. On the day after the storm, the Area Electronics Supervisor (AES) was able to get to Lihue on one of the military aircraft and made repairs at the WSO. However, transportation elsewhere on the island was impossible, so the AES returned to Oahu and the repairs to the outlying equipment were delayed for more than a week.

DST Recommendation: The NWS needs to improve the arrangement for providing ET services at WSO Lihue. Having an ET available on station would have expedited the recovery effort of the Lihue office. Also, the data retrieval from the various automated observing instruments scattered across Kauai could have been accomplished several days earlier had an ET been present.

Reconnaissance Flights

Aircraft reconnaissance was requested by the CPHC on September 8, 1992, at 1215Z. This was shortly after Tropical Depression 18-E was upgraded to Tropical Storm Iniki. These flights are requested and coordinated by the Deputy Director of the CPHC with the Chief, Aerial Reconnaissance Coordination, All Hurricanes located at NHC. The aircraft are based at Keesler Air Force Base (AFB), Mississippi. Because of the distances involved, at least a 48-hour advance notice is required. The first recon report, however, was received at 0432Z, September 10, 1992. One of the three available aircraft provided a fix enroute from the west coast of the mainland to Hawaii.

The CPHC received 12 fixes from the storm trackers extending until about 0930 UTC, September 12, 1992. Almost all flights were made at about the 700 MB pressure level (just above 9000 feet). The aircraft recorded flight level winds (from which surface winds were estimated), temperatures, and dewpoints.

These reports provided the most reliable information as to exact storm location, central pressure, and winds. This was especially true because of the acute viewing angle provided by the GOES satellite. NAVWESTOCEANCEN was especially strong in its endorsement of these data and requested, because of the inherent dangers to ships at sea, that such flights also be conducted for storms not threatening land. The DST concurs that these flights should be continued.

Radar Data

CPHC is equipped with displays allowing forecasters to monitor the weather radar unit at Hickam AFB and the air traffic radar located at the Federal Aviation Administration facility on Mt. Kaala, Oahu. These provided CPHC forecasters with an overview as Iniki approached Hawaii. The location of the Hickam radar, the more useful of the two units, is such, however, that mountains west of the site totally obscure all radar returns for storms within about 100 miles south of Kauai.

Another radar belonging to the Hawaii Air National Guard also provided some information to the CPHC. This air control and warning radar station is located on the northwest side of Kauai at Kokee. Although primarily used for directing and controlling aircraft, the radar was able to detect coarse features of Iniki. Until telephones lines were lost, duty controllers at the site telephoned the information in to WSO Lihue or relayed it through the Aeronautical Fixed Telecommunications Network to CPHC.

The eye of Iniki crossed over this site with no damage to the radar. Although not a recommendation from the DST, the structure and location of this site might provide useful information for the NWS' doppler radar unit to be installed on Kauai.

There were rumors on Kauai that Iniki had "two eyes." These were fueled by two separate pieces of information that found each other. Since Kauai is such a small island, this did not take long. Most people on the island had learned that the eye had passed near Waimea, crossing more to the western part of the island. However, due to topographic effects, winds on some parts of the island became quite weak, though not quite to the level of calm associated with an eye, as the winds shifted. This led some people on the eastern part of Kauai to believe that the eye had passed over them. These two impressions eventually met up and reinforced each other. We found no evidence to support a finding of two eyes. We also saw no evidence on Kauai that Iniki exhibited a concentric eyewall structure that sometimes develops in very intense hurricanes. After Iniki had mostly passed over Kauai, the radar at Kokee showed a gap in a strong inner rainband to the northeast of the center. Although it may have looked like two eyes, we attribute this to disruption of the rainband as it passed over the tallest part of Kauai combined with the lack of sensitivity to precipitation of this type of radar.

Chapter IV -- Preparedness

The real measure of a hurricane warning program is in the degree of response to the warning signals by the other federal agencies, Civil Defense (CD) managers, local officials, the media, and the public. In the case of Iniki, the response was outstanding. To the DST, this appears to be due to adequate education and training (i.e., preparedness) provided by all involved.

Credibility, aggressiveness, and a harmonious rapport are key ingredients to this process. This involves the NWS, emergency managers, key civilian officials, and the media. An active public awareness campaign through the media, on NWR, and in office tours and visitations fosters heightened awareness of local weather hazards to the general populace. When all is said and done, however, the scare presented by Iniki and the realization of what was and what might have been, may provide some of the best preparedness training ever available to residents of Hawaii, especially those on Hawaii's most populous island.

Central Pacific Hurricane Center (CPHC)

The CPHC is a subunit of WSFO Honolulu and is activated only when a tropical cyclone enters into or develops within the office's area of responsibility between 140° west longitude and the International Dateline and north of the equator. As used in this report, CPHC is identified for those tasks done by WSFO Honolulu staff that are specifically related to CPHC functions whether or not they are done when the CPHC is activated.

The CPHC is staffed by members of the forecast office. Although senior forecasters are usually selected to staff this desk, there is no set group. The DST believes that this is not conducive to establishing a body of expertise necessary for tropical storm forecasting. **DST Recommendation: NWS management should consider modifying the organization of CPHC to increase the capabilities and expertise of the unit.** One suggestion is to identify selected individuals to be a part of this unit. Along with this, management should consider providing this unit with opportunities for direct contact and specialized training, perhaps done in conjunction with the NHC, to enhance this proficiency.

Four individuals from CPHC are especially involved in the preparedness activities. They are the MIC for the WSFO, who also acts as the Director of the CPHC; the Deputy MIC of the WSFO, who is also Deputy Director of the CPHC; the WSFO warning preparedness program leader; and the WSFO hurricane and scientific services program leader.

It is important to note that the WSFO has only a program leader and not a warning and preparedness focal point. Whereas a focal point is allotted about 50 percent of his/her work time to these activities, a program leader does them while on shift or as time is available. The DST suggests that establishing a focal point position would enhance the awareness program by removing the primary responsibility from a management staff that often has too little time to devote to it.

Despite the lack of a preparedness focal point, some significant actions in this area have recently occurred. Since May, 1992, four meetings have been held with CD personnel from both the local

and state level. Hurricane awareness was the topic at three of the four meetings while two of them dealt with the flash flood program. Additionally, a hurricane drill was held on June 5, 1992, in conjunction with Hurricane Awareness Week. The staffs of the WSFO and the several Hawaiian WSOs (Lihue, Kahului, and Hilo) participated along with the military. Hurricane terminology and safety rules were highlighted on NWR in association with this and at periodic intervals through the summer.

In this same line, the Director of the NWS Pacific Region is a permanent member of the Meteorological Group, United States Pacific Command (MG PACOM). This group is composed of the various military agencies having meteorological detachments in Hawaii. The CPHC Director is an alternate member of this group and participates in its monthly meetings where coordination on operational requirements among member agencies is accomplished.

The overall CD program in Hawaii is a first class operation. The state office, headquartered in the Diamond Head complex east of downtown Honolulu, has oversight of the four local organizations (i.e., Hawaii, Maui, Kauai, and Oahu). The administrative head of each is a Deputy Director of SCD responsible for his/her area. The DST was especially impressed with the Oahu CD program. The Emergency Operation Center (EOC) is superbly organized. They have assembled a well-organized package concerning hurricane awareness and have done an excellent job in training the public to turn to the EBS station in the area for instructions when the sirens sound.

The backup system for the WSFO is a potential problem area. When it appeared that the existing backup operations plan may have to be implemented, significant problems were detected. Offices that were suppose to take over for Honolulu either had inadequate data resources, insufficient expertise, or a lack of manpower to do the job. **DST Recommendation: NWS management should see that the backup program for WSFO Honolulu is reviewed and necessary modifications implemented.**

National Weather Service Office (WSO) at Lihue

Around the United States, WSOs generally have responsibility for local preparedness programs with the MIC/OIC at each office being the program leader. In this regard, WSO Lihue oversees preparedness on Kauai and Niihau.

Niihau requires a short discussion. This is a privately owned island with little contact allowed from the outside world. The DST was concerned about the impacts of the hurricane on its residents and the disaster preparedness program there. However, overflights of Niihau indicated little surface damage, and the DST was not invited to visit the island. Because the NWS does not have routine contact with the populace of Niihau, and because of the location of the island in the weaker northwest quadrant with respect to the hurricane, the DST decided not to pursue investigations into that area.

On Kauai, the OIC has met regularly with local CD officials to develop and plan emergency strategies to be enacted in the event of a hurricane, tsunami, and/or flash flood and has been instrumental in an ongoing awareness program. As a part of this program, hurricane information is broadcast periodically before and during the hurricane season on the station's telephone recording. Also, the OIC has encouraged CD officials to place information concerning

hurricane terminology and emergency actions in the local newspaper, THE GARDEN ISLAND NEWS.

Additionally, the OIC has developed a good rapport with staff of the local cable television company. Although most programming comes from Oahu, there is a local news program "KAUAI TONIGHT." The broadcaster is a frequent visitor to the WSO for information.

From the actions of the island's officials and public, it is obvious to the DST that the preparedness program is working.

Chapter V -- Warning Services

The public, along with state and local officials, felt that the NWS had done a **fine** job on Hurricane Iniki with adequate lead time on the watches and warnings. Some quotes received:

“The system worked - they [NWS] did the best they possibly could within their capabilities.” Malcolm Sussel, Director of Oahu Civil Defense.

“Pretty good job - everything worked well - NWS helped make a critical decision.” Frank Fasi, Mayor of Oahu.

“Best job in 15 years forecasting Hurricane **Iniki**.” Tom Batey, Administrative Assistant to the Mayor of Kauai.

“Outstanding support - they [NWS] did a 1st class job - the system worked **fine** - a model.” Donald Gransback, Chief, Training, Education of the State Office of the Director of Civil Defense.

“The advance warnings of the NWS, the preparations and broadcast instructions of Civil Defense, and other government agencies functioned well in this emergency, though later critiques are likely to show areas of improvement.” Editorial from the Honolulu Star-Bulletin.

To ensure that proper procedures are followed, Weather Service Operations Manual (WSOM) Chapter C-41 provides instructions for the overall warning process from preparedness activities to the issuance of the various advisories and bulletins. The Station Duty Manual (SDM) is prepared from WSOM C-41 and contains **specific** details that each office must follow.

In the case of the CPHC, the WSFO Honolulu SDM (selections are included in Appendix B) is very **specific** in all activities from the staffing of the hurricane desk, the various issuance times of the various advisories/bulletins, local hurricane statements, a designated person to handle the media when the situation becomes critical, civil defense contacts, station supplies, electronic technicians alerted for extra coverage, when reconnaissance surveillance is required, requirements for a pre-season hurricane drill, and the need for a post-storm report. All these procedures were followed with the exception of the Hurricane Drill which was performed in early June (June **5th**), not in early May. However, the DST deemed that this was still well in advance of the peak period of the hurricane season.

WSO Lihue has explicit instructions in their SDM (see selections in Appendix B) on how to handle watches and warnings during an impending hurricane event. These instructions, dealing with obtaining wind/radar reports, **staffing**, civil defense/media notification, surface/upper air observations, the safety of the office and employee families, supplies, electronic technician support, the format for local hurricane statements, and post analysis of the event, are very thorough. During the Hurricane Iniki all procedures were followed in proper fashion.

The History of the Hurricane

The tropical depression that was to become Hurricane **Iniki** developed over the East Pacific Ocean near 12°N 135°W on September 5, 1992. This is somewhat farther west and south than the initial location of most middle season storms. It was initially labeled Tropical Depression Eighteen-E. On the morning of September 6, 1992, the storm crossed 140° west longitude into the Central Pacific (Figure 8). At 11 a.m. HST, CPHC was activated.

Initially, the system did not appear to be too significant and, at 5 p.m. HST on September 6, 1992, CPHC forecasted the system to dissipate within 24 hours. (Appendix A). At 8 a.m. on September 7, 1992, however, the depression reorganized. It was first upgraded to Tropical Storm Iniki at 5 p.m. that afternoon. When winds reached 75 MPH during the evening of September 8, 1992, the storm was further upgraded to Hurricane **Iniki**.

Hurricane Iniki continued on a west northwest course and passed 300 miles south of South Point on the Big Island of Hawaii. Winds near the center of the storm were estimated at 100 MPH. Up to this point, the movement of the Iniki was similar to that of other hurricanes which pass to the south of Hawaii.

However, developing weather patterns west of the Hawaiian Islands indicated that **Iniki** might not take the typical track south of Hawaii. Late on September 9, 1992, Kauai and Hawaii State CD (SCD) were briefed that Iniki could take a northward turn and, if it turned soon enough, could come close to Kauai. They were also advised that, if this happened, CPHC might have to issue a hurricane warning immediately without issuing a watch. The only question was how far west the forward momentum of Iniki would carry the storm before the turn.

At 5 p.m. HST, September 10, 1992, Iniki, which had begun to slow down earlier that day, ominously turned. CPHC issued a hurricane watch for the islands of Kauai and Niihau and for other atolls along the Hawaiian chain northwestward to French Frigate Shoals. By 8:30 p.m. HST, Hurricane **Iniki** turned to a more northerly track and the hurricane watch for Kauai and Niihau was upgraded to a hurricane warning. The eye of **Iniki** was expected to cross Kauai late on the afternoon of September 11, 1992. In addition, a tropical storm warning was issued for Oahu and a tropical storm watch was issued for Maui County (including the islands of Maui, Molokai, and Lanai). By 11 p.m. HST, the tropical storm warning for Oahu was upgraded to a hurricane warning.

By 8 a.m. on September 11, 1992, when the storm center was about 180 miles south of Kauai, Iniki had reached its peak intensity and was aimed directly at Kauai. A slight turn to the northeast, detected by radar for a few hours during the early morning hours, proved only to be temporary. By 1 p.m. HST on that day, the tropical storm watch for Maui was upgraded to a tropical storm warning.

At 3 p.m. HST, the eye of Iniki was just south of Kauai and its forward speed had accelerated to 30 MPH. The eye crossed the western half of the island between 3:20 p.m. and 4 p.m. HST passing again over the water about 4:10 p.m. HST. The storm continued to move north, and by 11 p.m. HST, all warnings had been discontinued. Iniki was downgraded to a tropical storm at 2 a.m. HST on September 13, 1992, and became extratropical by 11 a.m. HST on that date.

The departure of **Iniki** did cause some confusion for CD officials. Although the hurricane threat had ended, tropical storm force winds generated by **Iniki** were still prevalent. Therefore, as the winds were subsiding, the hurricane warning was downgraded to a tropical storm warning and then a tropical storm watch. This led some CD officials to wonder if another storm was coming. **DST Recommendation: CPHC should re-evaluate the procedures forecasters use when downgrading tropical storm and hurricane warnings.** Perhaps it should consider adopting the policy followed by NHC by which hurricane warnings are cancelled not downgraded as the storm is departing.

The DST also noted another major procedural difference between what is done in the NHC area of responsibility and that in the Central Pacific. No probability values for the hurricane's impact area are provided by the CPHC. Forecasters at NAVWESTOCEANCEN have a requirement for and generate probability cones for their internal use. Additionally, CD personnel plotting the forecast tracks do sketch in rough probability cones. **DST Recommendation: The CPHC should consider including probability cones or ellipses for all tropical cyclone marine and public advisories.**

Chapter VI -- Coordination and Dissemination

Overall, dissemination of information related to Iniki was handled in a timely manner. However, as noted in the paragraphs below, it was very labor intensive. Telephone calls and personal interviews with the media predominated. **DST Recommendation: CPHC management should consider alternatives to the current practice of having the duty CPHC forecaster answer telephone calls from users. DST Recommendation: NWS/CPHC Management should consider enhancing CPHC capabilities by a) reviewing the station's alerting procedures to see if a more efficient initial dissemination process can be developed, and b) establishing a Pacific Coordination Hotline similar to that currently serving the mainland United States.**

One obstacle to efficient dissemination is the old word processing equipment available to the CPHC staff. Numerous product corrections were required because of this equipment. The typographical errors disseminated due to the word processing problems were generally recognized and corrected by the users. **DST Recommendation: The NWS should replace the PRIME/TAB terminals used by CPHC forecasters for message composition with an up-to-date system.**

Coordination activities associated with Iniki were also quite labor intensive and sometimes required contacts with persons thousands of miles away. In general, these activities were satisfactorily accomplished although some problems were noted. Again, these will be discussed in the paragraphs below.

There are many groups involved when tropical cyclones occur in the Pacific Ocean. For the eastern Pacific, the 140° longitude line divides NHC and CPHC responsibility. USAF, USN, and NWS facilities and resources are all involved in the warning process. Because of this, it may be that the current responsibility structure is not as efficient as it could be. **DST Recommendation: The DST suggests that, taking into account the available expertise within the agencies involved, the geography of the Pacific Basin, and the government's changing fiscal climate, a detailed look at the hurricane warning structure in the Pacific, involving the USN, USAF, and NWS, be undertaken. In so doing, the DST affirms its belief in the importance of having a separate hurricane center in the Pacific.**

State Civil Defense

During Hurricane Iniki, the SCD coordinated operations of state and federal assets (e.g., the Hawaii National Guard and the Federal Emergency Management Agency [FEMA]) with the CD operations of each island. The SCD had little direct interface with the CPHC relying instead on the Hawaii Warning System (HAWAS), the inter-island version of the National Warning System (NAWAS) which is used across the mainland United States, and the state CD communications circuit, an inter-island data network that also relays NWS material to emergency managers throughout the islands, for its information. Most of the direct CPHC coordination was with Oahu Civil Defense (OCD) officials.

SCD primarily uses dedicated phone lines for information, coordination, and command and control purposes. This is supplemented and backed-up by a radio network of volunteer amateur

radio operators. When Iniki knocked out telephone lines to SCD operations, these operators were used until the National Guard set up a closed network of satellite radios. Although SCD has the ability to locate amateur radio operators at the CPHC, this was not done during Iniki.

Other communications links between the NWS and SCD operations include the only non-NWS NOM Weather Wire Service (NWWS) receiver in the state and the NWR. Neither was perceived by the users as a principal weather information resource, however. The NWR was knocked off the air at a very critical time from 4:35 p.m. HST on September 11, 1992, until 3:25 p.m. HST on September 12, 1992. The failure was caused by a microwave outage from Diamond Head to the receiver at Mt. Kaala. When this occurred, reception statewide was lost.

Oahu Civil Defense

The OCD operational manager assessed the coordination between OCD and CPHC during Iniki as good but not ideal. OCD would like to receive severe weather warnings sooner to better facilitate public evacuation procedures. Over the last year, CPHC and OCD conducted an effective program that had personnel at each office make informational tours of the other's facilities. As a result, the CPHC and OCD staffs were acquainted and knew each other's mission so that there was an accelerated and efficient flow of information during Iniki.

The local CD office began tracking the storm with the CPHC almost 72 hours prior to landfall. When the CPHC issued the tropical storm warning, the OCD EOC was ready and immediately began operation. It remained in regular contact with the CPHC via the EOC's 50 telephone lines.

Telephone was the primary mode of communication between the EOC staff of emergency managers (mayor, police, fire, transportation, highway), their personnel, and the CPHC throughout the storm. The EOC is also equipped with NAWAS, HAWAS, and the inter-island CD communications circuit. Volunteer amateur radio operators again are used as a back-up communications system. The OCD operational manager expressed concern as to the EOC's over-reliance on the telephone communication network. As was shown during Iniki, it could be rendered useless during severe weather.

CD sirens that reach over 85 percent of the population of Oahu did an effective job of informing the public of the approaching storm. CD officials did not sound the sirens when the warning was first issued. They decided that it would be more effective to do so early on September 11, 1992, just before the morning rush hour. However, there was some public confusion over what to do when the sirens sounded. The standard operating procedure, advertised in many places throughout the state, calls for people to turn on their radio and listen for instructions. Some people, however, especially those in outlying areas, took the siren as a signal to move to the evacuation shelters.

Another concern is that the siren system cannot be turned on selectively to separate parts of the island. All persons are warned at the same time even though the timing or magnitude of the threat may be quite diverse. OCD is looking into procuring a selective siren system.

Honolulu Media

The media hub of Hawaii is located in the city of Honolulu, Oahu. There are 32 radio stations, six television stations and two daily newspapers serving the island of Oahu. Many of the Honolulu-based media serve as the primary source of news and weather information for the people of Kauai as well. Lihue, the main city of Kauai, is about 100 miles northwest of Honolulu.

Unlike most of the United States mainland, weather on the Hawaiian Islands varies only slightly from day to day. As such, weather reports generally receive low priority. As one newscaster put it, "Weather is only a story if it is the headline story."

In general, coordination with the CPHC was described by the media as "timely and accurate" and "cooperative in a time of increased burden." Most media felt the CPHC provided adequate warnings that allowed them to "gear up" for the storm. However, initial dissemination procedures for warnings issued by the CPHC need to be reviewed. The DST was amazed at the long telephone call list (included in Appendix B) used by the staff.

Throughout the area, the media generally rely on the Associated Press (AP) wire service as the primary source of weather information. The staff at one of Honolulu's daily newspapers, though, admitted to picking up Iniki's initial weather advisories through their police radio scanner. Neither the NWWS nor the NWR is used by any of the media. For NWWS, cost is a major factor. However, many were surprised to learn of the NWR's low cost and plan to invest in a receiver.

Although staff at one newspaper stated that they consider some of the weather data hard to interpret, most were content with the wire information they were receiving until their AP receivers were lost due to high winds. This occurred early Friday afternoon as the fury of the storm was approaching. Subsequently, the media relied solely on their only other conduit of information from NWS--the telephone. Several media personnel asked that a key word be placed on the AP wire that triggers the lights and alarm on the printer to better draw attention to the latest incoming weather bulletin.

The WSFO had given area media and emergency managers several unlisted telephone numbers to use for contact and coordination. The media used the unlisted numbers but, in some instances, complained that they had a hard time getting through the busy lines. The DST suggests that designating one line as a media hotline, restricted only to the media, be contemplated.

During normal operations, the WSFO receives several media queries a day. During Iniki, CPHC personnel fielded constant calls from media and emergency managers around the clock. This substantially took them away from their normally assigned duties. The office does not have the manpower to dedicate a person to answering these calls. As a result, calls were answered by anyone who had a free moment. Although consistent information appeared to have been given out in this situation, a single point of contact would produce a much greater surety of this. The DST suggests that CPHC be staffed during such circumstances so that, similar to what is now done at the NHC, a single spokesperson can field media and CD questions. Perhaps staff members from Pacific Region headquarters can be used.

The main NWR transmitter for Oahu is on Mt. Kaala. A relay damaged by high winds put the transmitter off the air during the afternoon of September 11, 1992. Because this transmitter also drives transmitters on Kauai, Maui, and Hawaii, this damage effectively eliminated all NWR coverage during the height of the storm, and for about 48 hours following, over all of the impacted area. **DST Recommendation: The NWS should review the current NWR system to see if an alternative can be arranged whereby all NWR transmitters in Hawaii function independently.**

None of Honolulu's three affiliate television stations employs a meteorologist. One station has a full length weather report given by a "weather specialist." He provided full coverage during the storm build up. The other stations rely on an anchor person to read the weather forecast. Station managers implied that the hiring of a full-time meteorologist would not be cost effective considering that the weather is relatively stable. When the storm became the major news item, these stations used in-house reporters for coverage. Again, the telephone was the major vehicle for keeping informed of CPHC issuances and information.

Two of the stations have each recently acquired a WSI Corporation weather satellite imaging system. One station was having the equipment installed the week Iniki hit and had a WSI technician on site during the storm to help inexperienced staff members interpret the data and images. Both stations stated that they call the WSFO at least daily for help in deciphering the WSI maps they receive. The weather specialist from one television station said he was "trained" by the WSFO staff over a period of several years to be able to interpret the NWS and WSI data and charts. That station plans to have their new weather personality "trained" in the same manner.

One of Honolulu's radio stations sent a member of their staff equipped with a cellular telephone to the CPHC during the storm. This gave that station instant telephone contact between the CPHC and the radio news room while other media remained frustrated by busy lines. If other media had done the same, the forecast section of the CPHC would have been grossly overcrowded. The DST suggests that CPHC management consider establishing a media briefing room and providing frequent (e.g., hourly), regularly scheduled briefings during future storms. Further, the media needs to be educated concerning the capabilities and time schedules of the CPHC so they are aware of its limitations.

Several of the media expressed concern over the loss of the Pacific GOES weather satellite and the subsequent repositioning of the other GOES. They wonder whether that "quick fix" serves the interests of the Hawaiian public.

Naval Western Oceanography Center (NAVWESTOCEANCEN)

NAVWESTOCEANCEN provides forecasts for the USN's Pacific Region and is responsible to the Pacific Fleet Commander for the safety of all ships located in Pearl Harbor. As does the CPHC, NAVWESTOCEANCEN receives unclassified weather information from the NWS, data from weather recon flights, and data from the Hickam AFB, Hawaii, radar. It also obtains classified weather data from ships at sea not available to the CPHC and polar satellite data forwarded from FNOC. Using this information, NAVWESTOCEANCEN tracks tropical storms on its own.

Because of its capabilities and mission requirements, the USN has need for long warning lead times. For example, unique to the USN port in Pearl Harbor, there is one channel of access in and out flanked by shallow areas. This creates extreme navigating difficulties for ships. Cross winds of 35 MPH (30 KT) or more play havoc with in-channel steerage. Winds of 58 MPH (50 KT) or more directly onshore can create 20 to 25 foot waves at the shallows near the harbor's entrance which can swamp inhabited parts of the Pearl Harbor complex. Therefore, NAVWESTOCEANCEN needs a longer lead time for taking action so that they can sortie ships out of the harbor. NAVWESTOCEANCEN says that it requires 48-hours to safely secure Navy assets at Pearl Harbor. **DST Recommendation: The CPHC should elicit from users critical wind and sea height values and should highlight these in appropriate tropical cyclone products.**

The only communication link between NAVWESTOCEANCEN and CPHC is land line telephone. NAVWESTOCEANCEN is not hooked to the state CD communications circuit and sees no need to be. During Iniki, NAVWESTOCEANCEN knew of only one unlisted number over which to contact the CPHC. Staff said it took about a half hour to reach CPHC on it. NAVWESTOCEANCEN requested that a hotline be established between the two offices.

The DST believes that a more comprehensive communications system, something like the hurricane hotline in place along the Atlantic Coast, would add significantly to the interagency coordination and recommends that this be considered. The DST also notes that when, due to communication's failures in Honolulu, NAVWESTOCEANCEN turned its duties over to the JTWC in Guam, coordination links between that agency and CPHC were even more tenuous.

Although both agencies were aware of the storm earlier in the week, coordination between NAVWESTOCEANCEN and CPHC first started on September 9, 1992. By 5 p.m. HST on September 10, 1992, NAVWESTOCEANCEN had passed the critical 48-hour point and recommended that the USN sortie all ships out of Pearl Harbor. Prior to this recommendation, NAVWESTOCEANCEN and CPHC had agreed that a watch would be issued by CPHC at the next scheduled update. It is the usual practice that NAVWESTOCEANCEN will follow the CPHC lead on tropical storm products. This is done because CPHC has the responsibility for issuing tropical cyclone warnings within the central Pacific and to minimize any confusion due to the large military population in Oahu. However, the time criticality of the situation to the USN led them to sortie the ships, an action that increased phone calls from the civilian population to the CPHC.

NAVWESTOCEANCEN staff expressed frustration about two WSFO forecast amendments that occurred on September 11, 1992 relative to the course of the storm. The ramifications of one of these amendments was significant in that the USN had to decide about evacuation of certain coastal areas within its Pearl Harbor complex.

Situations, such as those occurring in Iniki, require close coordination and cooperation between the two groups - CPHC and NAVWESTOCEANCEN. **DST Recommendation: Better rapport needs to be developed between CPHC and NAVWESTOCEANCEN.** Using the existing mechanisms (e.g., the monthly MG PACOM meetings), the DST believes that efforts to strengthen the coordination schemes already in place should continue. A review of communications between the two groups during Iniki and possible areas for closer collaboration should be undertaken.

Coast Guard

There are two principal methods used in Hawaii for alerting mariners at sea of approaching storms. The first is the NWR. To quote one of the state CD officials, "All boaters in Hawaii have NWR receivers and use them." The NWR broadcasts included all appropriate marine products and, until the transmitter went down, kept mariners informed.

The second method is accomplished by the USCG COMSTA located in north central Oahu. The COMSTA is essentially a pass-through station whereby various marine oriented products are received and broadcast to mariners across the entire Pacific Ocean. High seas, offshore, and coastal waters forecasts issued by WSFO Honolulu are broadcast on a scheduled basis over several radio frequencies.

One problem was noted here. The NWS and the USCG have established a list of products that the COMSTA will broadcast. The tropical cyclone marine advisory is not one of these. According to NAVWESTOCEANCEN, however, this is the most important product they receive from the CPHC. Because of the value of the product to this and other users, the DST believes that it ought to be included in the USCG COMSTA schedule. **DST Recommendation: The NWS should review the list of products broadcast by the USCG COMSTA in Hawaii. Tropical cyclone marine advisories should be added to the list.**

As with their land-based counterparts, there is every indication to the DST that all mariners were aware of the approaching storm well in advance of its arrival.

Kauai Media

The WSO in Lihue deals directly with the media on Kauai either via the telephone or by site visits to the WSO office itself. Kauai is served by several AM and FM radio stations spread throughout the island. Two cable television operations split service to about one-half of the island's residents. Residents receive daily news and weather from Kauai radio stations or the Honolulu-based television stations fed through the two cable companies. In addition, the Kauai public has available both a daily and a weekly newspaper.

On the leeward (south and west) sides of Kauai, an hour long public access cable program includes a local Kauai weather forecast. This airs on weekdays three times a day. The on-air personality visits WSO Lihue each day an hour before the show goes on the air to collect the forecast. The WSO alerted him as early as September 7, 1992, of the storm's track toward the islands. He remained in contact with the WSO via the telephone and, at 10 p.m. HST on September 10, 1992, programming was interrupted to inform the public of the hurricane warning issuance. The cable TV station went off the air the afternoon of September 11, 1992, with no power and with wind damage to their antenna. Although he visits the WSO each day and owns a NWR, the on-air personality said he heard unofficial word that a hurricane warning would be issued on his police radio before the WSO actually did.

Kauai Civil Defense

WSO Lihue maintains close ties with Kauai's CD organization. CD authorities have installed radio equipment in the WSO that is generally capable of allowing contact even if telephone lines go down. Unfortunately, Iniki destroyed the antenna on the Kauai CD EOC so that this link was unusable during most of the storm and its aftermath.

On September 7, 1992, the OIC of the WSO alerted CD officials and radio station KONG, the Emergency Broadcast System radio station for Kauai, of the impending storm. KONG does not have a NWR nor a NWWS drop and normally receives weather information over the AP wire. They rely on land line telephone communications with WSO. As an aside, the DST found it interesting that the NWWS receiver located at the WSO was the only communications system that remained operational at that station throughout the storm.

The CD organization also has a drop on the HAWAS and the CD communications circuit. This direct voice contact with CPHC is not available to WSO Lihue. Thus, the CD knew about the hurricane warning and began dissemination procedures even before the WSO did.

Information updates were provided over these various systems and through personal contacts until the storm hit. When that occurred, all links, including the radio links with the Kauai EOC, were severed.

Between CPHC and WSO Lihue

Telephone communications provide the only coordination link between the CPHC and any of the Hawaiian WSOs. Besides telephones, this includes the CD communications circuit and the LABS circuit by which weather products and observations are transmitted and received. NWWS drops do allow WSOs to receive satellite relayed products, but do not allow local transmissions.

Routine communications between Lihue and CPHC remained intact until Iniki hit. Once the telephone system was destroyed, the CPHC had no direct contact with Lihue for over 3 days. A HAM radio message was forwarded on the morning of September 12, 1992, 12 hours after the storm, informing CPHC and the NWS Pacific Region headquarters as to the status of facilities and personnel at Lihue.

Between CPHC and the NWS Pacific Region Headquarters

The NWS Pacific Region opened and staffed a hurricane watch office coincident with the issuance of the hurricane watch. This was located in the regional headquarters building in downtown Honolulu. The communications and backup power capabilities of this facility allowed the regional representative to monitor ongoing activities and provide important coordination between the CPHC, the Pacific Region, and the NWS headquarters, and with the Commander of the 14th Coast Guard District, colocated with the Regional facility.

Chapter VII -- User Response

In the words of an official from the Hawaii office of the Director of Civil Defense, the response of everyone to Hurricane **Iniki** was 'textbook.' From the view of the DST, this statement was quite accurate. As shown in Figure 21, the spirit of the people continued to be high even during the cleanup.

There are generally four primary users for CPHC products. These include the media, the state and local CD agencies, the public (including mariners), and the military.

The Media

When it became obvious that **Iniki** would hit Hawaii, the media, especially that on Oahu and Kauai, turned its full attention to the storm. In response to early statements from the NWS, the radio and television alerts were being given on Wednesday evening, 48 hours before the storm hit. On Thursday evening, when the western islands were placed under a hurricane watch, some of these stations began 24 hour coverage dedicated solely to the storm.

When the sirens were sounded on Friday morning, the radio stations, using NWS statements and direct telephone contact with NWS staff, provided a steady stream of information by which the public was alerted to the location, movement, and intensity of the storm. The media also disseminated safety information from the state and local CD authorities.

The AP network, the major conduit for providing NWS products to the media, was interrupted early Friday afternoon. When this occurred, the telephone contacts became the only source of information to the media. The radio stations and the local television station on Kauai were off the air soon thereafter, the result of lost power and antenna damage. However, Oahu media continued providing Kauai residents with the latest information available.

The response of the media to the storm was excellent. The reliance on telephone contacts, however, should be reviewed. During times of intense workload, these contacts may become **difficult** and may actually become a detriment to the overall dissemination of vital information. It may be that the NWS should more aggressively encourage the local media to install and use the NWR and NWWS. Currently, these are not important sources for distributing weather information in Hawaii to the broadcasters.

Civil Defense

Early (September 8, 1992) discussions between the NWS and state and local CD authorities allowed an extremely well organized system to get ahead and stay ahead of the approaching hazard. Emergency service operations were initiated well ahead of time. The onset of sustained winds of 40 MPH, the defined lower limit of gale force winds, are a milestone for CD officials. They plan to have all evacuations completed by that time. By noon on Friday, about the time this speed was reached, most evacuation plans had been completed.



Figure 21. Aftermath of Hurricane Iniki in Princeville. (Photograph Courtesy of William Alder)

The state CD circuit distributed the latest weather information to all officials. The breakdown of this circuit, when communications links were interrupted, came after most preparations had already been made. However, a more secure system, not relying on telephone communications, needs to be investigated.

The only disparaging comments heard were on northern Kauai where residents wished that the sirens could have been sounded when the warning was issued on Thursday night, the night before Iniki hit. They believed that this may have given residents more time to prepare for the storm.

The sirens are a definite key to alerting the public. Throughout the survey area, the DST heard time and again of the importance the general populace places on this alert method. When the sirens sound, the public believes that something bad is soon to hit. The sirens were sounded at about 5:30 a.m. HST September 11, 1992, on both Oahu and Kauai. This was done after coordination between state, local, and Federal officials on the islands. It was done at that time to ensure that the populace would be alerted as they were getting up and preparing for the day; before people left home for work and school. The sirens were again sounded about 4 hours later to reinforce the warning.

Public

In many past surveys, the reaction of the public to severe weather episodes has been less than desirable. However, in the case of Iniki, this was not the case. The DST was overwhelmingly impressed by the way the populace responded. In many cases, we had a difficult time in determining what had occurred (e.g., time and duration of eye passage and weather conditions during the eye passage) because everyone had evacuated an area and gone to designated shelters. The low number of deaths and injuries attributable to Iniki can be directly related to the outstanding preparation by the NWS in Hawaii, the Hawaiian CD system, and by the response of the media and the public.

Regarding shelters, the DST saw several examples of these that were damaged. The skylight in one hotel ballroom was ripped off the roof. The roof of a gym was blown off. **DST Recommendation: The NWS should encourage the State of Hawaii to review its criteria for disaster shelters to make them more appropriate for hurricanes. Expanded criteria may exclude facilities where the room ceiling is also a roof and rooms with windows from being a shelter.** For such storms, small interior rooms or hallways where people are not concentrated generally offer more protection.

The responsiveness seems to have been greatly helped by the recent experiences of people in Florida and Louisiana associated with Hurricane Andrew. The Hawaiian public had the facts of just how destructive a Category 3 or Category 4 hurricane can be through video tapes of Andrew's path through Dade County in south Florida about three weeks prior to Iniki. The comparisons between Iniki and Andrew were very effective.

Also, Hurricane Iwa, that caused widespread destruction on both Kauai and Oahu 10 years ago (November 1982), was still clearly remembered. The winds with Hurricane Iniki were much stronger than Hurricane Iwa, but with Iwa, the radius of strong winds was much greater. In this regard, the overwhelming consensus was that the NWS learned a great deal from Iwa and performed much better during Iniki.

Kauai

When the sirens were sounded, most of the people on Kauai did exactly as they were supposed to do. They began gathering supplies or heading for designated shelters. Although sirens do not cover the entire island, neighbors and local emergency officials made sure that others were aware of the storm. The DST heard tales of condominium and apartment managers going from door to door to ensure their people were making preparations. One manager worked so long in getting his people out that, when the storm hit, it was too late for him to evacuate. He rode it out in his interior bathroom watching the roof and walls of his home blow away.

There were also stories about motorists honking their horns to spread the warning in places where the sirens could not be heard. The DST could find no one who had not heard about the storm; everyone knew what actions they should have taken. The town of Lihue, the largest community on the island, was described as a ghost town by 11:30 a.m., about 4 hours before the eye of the storm reached land. A few people in Kauai did refuse to leave their homes. However, in every case they knew about the storm and were aware of the dangers involved.

The sirens hold great importance especially to those on Kauai. The impression given to the DST was that warnings are largely ignored until the sirens are sounded. In this case, even though the warning was issued the previous evening for Kauai (8:30 p.m. HST), actions were not generally taken by the public until the CD people sounded the sirens at about 5:30 a.m. HST on September 11, 1992. This may be a cause of concern for local officials. **DST Recommendation: The NWS, in coordination with Hawaiian CD officials and with the help of the media, should conduct a public awareness campaign to educate the public on the importance of watches and warnings not accompanied by sirens.**

Oahu

On Oahu, the public response was also excellent with evacuation shelters beginning to fill up during the morning hours of September 11, 1992. Local officials delayed sounding the sirens the night before reasoning that they would give the alarm as people were getting up in the morning before they could leave. Coordination between local and other officials ensured that only the most critical employees reported to work. Schools and most businesses were closed.

The state CD should investigate differences in perception held by residents in various parts of Hawaii as to what is meant when the sirens are activated. In Oahu, residents generally seem to understand that it means to turn on the local radio station. In Kauai, however, it generally is understood to mean evacuate.

Navy (USN)

As noted above, the mission of the USN requires somewhat longer lead times than is required of the other users. Usually, the coordination discussions between NAVWESTOCEANCEN and the CPHC allows these requirements to be taken into account. However, the DST believes that it is very important for the NWS to be aware of these requirements, and those of other users, and, when appropriate, highlight them in CPHC issuances. This would focus attention on the critical values and assist decision makers during such hectic times.

Discussions with the NAVWESTOCEANCEN staff indicated to the DST one area where knowledge of such requirements could apply. During the afternoon hours of Wednesday, September 9, 1992, the possibility that Iniki would turn north and adversely impact the USN fleet docked at Pearl Harbor was of great concern to the commander of NAVWESTOCEANCEN. NAVWESTOCEANCEN personnel and CPHC forecasters seemed to agree that Friday afternoon was the most likely time of impact if the storm did turn north. Therefore, Wednesday afternoon, 48 hours before the projected time of the storm, was a critical decision point for the USN. NAVWESTOCEANCEN recommended that preparatory actions be taken. On Thursday, September 10, 1992, the USN again reached a critical decision point, 24 hours before projected storm time, and NAVWESTOCEANCEN recommended that warning related activities be initiated. Both recommendations were made after consultations with the CPHC. Because of the large number of Navy people involved and their visibility to the local community, these preparations and activities, preceding a watch or warning issuance, could have caused some public confusion. In the case of Iniki, the increase in public telephone calls to the CPHC indicates that this indeed may have happened.

The nighttime update accomplished early Friday morning scared the NAVWESTOCEANCEN officials. Apparently, this change was made with minimal coordination between CPHC and the USN. It resulted in actions taken by the USN that caused some evacuations of USN facilities on Governors Point and caused discussions about evacuating Ford Island. Although the storm stayed well to the west and USN facilities in Oahu were only minimally impacted, the problems highlighted by Iniki between the NWS and the USN need to be examined and rectified.